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**How important is Financial Sector to Price Indices in an Inflation Targeting Regime? Empirical Analysis of the UK and the US**

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**ABSTRACT**

This paper investigates whether incorporating stock prices into the price index that will be targeted by the central bank can be more beneficial in terms of economic stability. It also looks into the question of whether central banks should use stock prices as a component in the output stability index. Optimization technique is used to estimate optimal weights for different sectoral prices. The weights, which depend on sectoral parameters, are different from those used in computing the consumer price index. Using data for the UK and the US, the results suggest that using the constructed broader measure for inflation achieved higher output stability than using the consumer price index. The results, therefore, highlight importance of having a broader measure of inflation in improving macroeconomic stability in an inflation targeting monetary policy environment.

**Keywords:** Stock prices, Output Stability Index, Inflation Targeting, Fundamental, Bubbles
**JEL Classification:** D53, E31 E58, G12

## 1. Introduction

Over the past twenty years, inflation targeting, IT, as an objective of monetary policy has been adopted and implemented by central banks of developed countries. This has had important implications for sustainable price stability over the last two decades. IT period also coincides with the period of 'great moderation' that not only addresses high inflation, but to a large extent avoided economic recession until the advent of the financial crisis. Despite the financial crisis that forced many central banks to embark on non-conventional policies in form of quantitative easing, QE, IT is still at the core of these countries' central banks' policy-making decisions. As IT is characterized by declaring numerical inflation targets, this therefore, makes role of inflation forecasting critical. This requires a high degree of clarity and accountability (Svensson, 1999a, 1999b, 2002; Clarida et al., 2000 and 2001; Woodford, 2004). In addition, most recent work on monetary policy seems to suggest that objective of the central bank should be to stabilize both the output and inflation (Abo-Zaid and Tuzemen, 2012; Kurozumi, 2012; Svensson, 2011). Stabilization objective of IT is found in the central bank's efforts to minimize quadratic social loss function; which responds to deviation in inflation and output (Svensson, 2002). Therefore, central bank should include not only inflation, but also other variables such as output gap (stabilizing resource utilization) as target variables. In both theoretical and empirical literature, it is acknowledged that central banks should adopt IT in such a way that it does not either cause or exacerbates economic fluctuations (Cecchetti et al., 2000; Cecchetti and Kim, 2003; Mankiw and Reis, 2003).

Policy makers have used different methods in their attempts to control inflation and minimize its damaging effect on the economy, seeking to reduce inflation or maintain it at a level that is consistent with the overall objective of economic growth and stability. Consumer price index (CPI) can be modified to exclude certain components such as food prices, energy prices or indirect taxes; under the assumption that these components provide relatively little information about the underlying inflation. Clark (2001) indicated that food and energy prices are highly volatile because of supply shocks such as drought or oil price shocks. Fluctuations in food and energy prices are seen as temporary movements, and therefore policy makers may not want to react to transitory changes in inflation, which are often related to supply disturbance. Furthermore, these movements represent supply shocks and are non-monetary in nature. Generally, the main concern of the policy makers is to find an inflation measure that can be regarded as "core inflation" that excludes certain components that are subject to large relative changes. As an indicator of future inflationary pressures, the central bank should use explicit or implicit inflation forecast targeting thereby paying close attention to core inflation (Eusepi, et al., 2009).

The CPI, as constructed in many countries, covers only a section of the cost of living, and assets prices such as real estate or equities are excluded. Existing literature recognizes that such price indices may not be suitable for the purposes of conducting monetary policy (Mankiw and Reis, 2003; Goodhart, 2001). It is argued this is so because that a price index it does not target future expected inflation (Alchian and Klein, 1973; Kent and Lowe, 1997; Shiratsuka, 1999; Goodhart, 2001). Financial sector fluctuations can have a significant effect on the real economy and should therefore play a role in monetary policy decisions. Asset price variations have an impact on expenditure decisions made by households and firms. An increasing asset value makes people richer and may support additional spending. Rising (falling) asset prices increases (decreases) the cost of asset financing and might encourage (discourage) investment. Such arguments are borne out of the Japanese experience in the 1980s, asset price bubble in the US stock market crisis of 1990s and the 2007 US sub-prime mortgage market crisis.

IT regime has been successful in keeping inflation low and stable, but there has been growing concern that the achievement of stable prices may be related to amplified risks of financial instability. Kent and Lowe (1997) argued that increases in asset prices tend to have small direct effects but large indirect effects through their impact on the financial structure. They stated that after asset price increase, financial institutions have expanded credit to purchase assets or accepted assets as guarantees for loans.

This leads to the question if central banks should directly respond to stock price volatility in formulating its monetary policy? The major reason for this is that asset prices bubbles create inflationary/deflationary pressure on investment and consumption, which leads to variability in both output and inflation. Large swings in asset price, particularly stock prices, in many countries between 1980 and 2010 have had significant effects on the real economy. For instance, a sustained increase in equity prices in Japan in the late 1980s and the South-East Asia stock market crash in 1997-98 were associated with poor economic performance. A second related question is whether monetary policy in both industrial and developing economies should respond to asset price booms and busts, which have been significant causes of economic fluctuations. There are two school of thoughts on this: (1) the first school, following in the work of Bernanke and Gertler (1999, 2001) stated that monetary policy should not respond to developments in asset prices until they indicate changes in future inflation. Their main argument is that it is not easy to forecast bubbles[1] but that if an asset price bubble can be identified, then altering interest rates would be an inefficient way to burst that bubble (Bernanke and Gertler, 2001; Schwartz, 2002). The second school of thought takes a different view. It follow in the arguments of Ceccetti et al. (2000), Blanchard et al. (1993), and Bordo and Jeannne (2002), that portend monetary authorities should give substantial consideration to asset price fluctuations as well as aggregate price movements in order to reduce misalignments that will help in minimizing the risk of macroeconomic instability. It further argues that asset prices may be a useful indicator in forecasting static inflation. It also suggested that asset prices can have strong pro-cyclical effects, which can also affect the stability of financial markets. The group, therefore, recommended that central banks should react to the fundamental movements of asset prices through the interest rate in order to achieve stability in financial markets and the real economy. Kent and Lowe (1997) pointed out that one of the reasons that a monetary authority should target movements in financial sector is that these movements can create future difficulties in the financial system, which will affect future output and inflation. Therefore, a number of economists recommend that the central bank should include financial sector (asset price) in the aggregate target price index (Matalik et al., 2005; Goodhart, 2001; Goodhart and Hofmann 2000). Alchian and Klein (1973), Goodhart and Hofmann (2000), and Goodhart (2001) demonstrate that a price index used to measure inflation should not only incorporate the prices of goods and services but must also include the future prices of goods and services which are reflected in current asset prices. They maintain that a broad measure of inflation should anticipate changes in the monetary cost of a basket of current and future goods and services, and as such a good measure of inflation should take into account asset price changes as well. Goodhart (2001) contends that inflation is a fall in the value of money, not an increase in the CPI[2]. Cecchetti et al. (2000) reported that central banks could improve macroeconomic performance by adjusting interest rate by taking into account asset prices when aiming for inflation and output stability. Therefore, IT regime should involve raising the interest rate during an asset price boom and cutting the rate down during an asset price bust.

[1] An asset price bubble is that part of asset price movement that is unexplained.
[2] For more details, see Goodhart (2001), pp. F335-F338.

This study supposes that a central bank commits itself to achieving an inflation target and considers what measure of the inflation rate that is more appropriate for the central bank to use in stabilizing the real economy. Therefore, the paper fills in the gap that exists in the literature by answering the following questions; (i) should a central bank target the price index that not only incorporates current costs of living but also future prices? (ii) whether a central bank should incorporate financial sector in computing the price index to target? (iii) how important is price stability in explaining the stability in the real economy? This study does not focus on how the central bank is to achieve its target. However, it does address a crucial problem faced by the central bank, namely the construction of an appropriate price index and how to assign weights to different sectorial prices.

The main contribution of the paper lies in its construction of a price index that will be more appropriate to target by a central banks that implements an IT regime that combines the financial sector with the traditional CPI components. This is done in order to find out, which of these indices that stabilizes the real economy as well as producing price stability. In addition, the paper further proposes to explore whether a central bank should use incorporate asset prices while computing their price indices. This study applies Mankiw and Reis (2003) optimization approach to assign weights to difference sectoral prices (dependent on sectoral parameters that differ from those applicable to the CPI). This approach refers to price index that monetary authorities use as an “Output Stability Index (OSI)”. Uniquely, this study uses a generalized method of moments (GMM) to estimate parameters of the model and derives a four-sector algebraic solution. One of the advantages of using GMM is that it employs orthogonal conditions, which minimize the correlation between idiosyncratic shocks and explanatory variables. Additionally, the variance of output gap is computed separately using OSI and CPI, to examine the gain in economic stability achieved by targeting OSI rather than CPI.

It is in light of the above argument that the paper uses the UK and the US data. These are both economies that have predominance of financial markets in their economies. The parameters and optimal weights are estimated for three different combinations of sectorial prices for the countries, which provide a broader picture of the results thus leading to more robust and precise conclusions. In this context, the paper further distinguishes between fundamental and bubble components of the stock prices. Together with energy, food and other goods prices, three models were considered; the first model uses actual stock prices, the second uses the fundamental component of stock prices while the third one uses the bubble component of stock prices.

The rest of the paper is set out as follows. Section 2 locates and explains the problem and also derives a four-sector algebraic solution to the central banks' problems. Descriptions of the data, the estimation procedures and methodology. the structures of the stock markets and the decomposition of the aggregate stock price into fundamental and non-fundamental components are discussed in Section 3. Empirical results regarding the optimal weights, parameters and stability price indices constructed are presented in Section 4 and Section 5 concludes.

## 2. The Basic Model: Solving for the Central's Bank Problem

A central bank that implements IT policy faces a problem how to choose appropriate weights for a price index that it uses as a measure of inflation, which would lead to minimizing the volatility in output. Mankiw and Reis (2003) model this problem using several differing sectorial prices with regards to four characteristics[3]: (i) the budget share and CPI price weighting of various sectors; (ii) changing economic conditions that affect the flexibility of some prices but not others; (iii) prices that are highly responsive to the business cycle in some sectors, while less so in others; (iv) comparatively high levels of idiosyncratic shocks in certain sectors. The existing literature allows for the inclusion of sectoral differences and their implications for monetary policy (Aoki, 2001; Mankiw and Reis, 2002). In addition, Mankiw and Reis (2003) suggest several propositions that can be obtained from these optimal weights to shed light on the nature of the solution. The summary of their propositions is that if the two sectors have different characteristics, then, the OSI assigns to them varying weights, and when two sectors have same sectorial characteristics, then, the OSI assigns them equal weights. The results are more appealing when the sectorial characteristics diverge, as this reflects the asymmetry of the two sectors. Hence, this problem centres on determining optimal weights in a target price index. If this price index is used as the core measure of inflation targeted by the central bank, it will lead to greater stability in economic condition (output gap) as defined by stability in the price index. The central bank's problem can be represented as follows:

$$\min_{\{w_m\}} \operatorname{var}(z_t) \qquad \text{for } m = 1, 2, \ldots M; \qquad t = 1, \ldots, n \qquad (1)$$

[3] See Romer (2012) for details.

where $z_t$ represents the output gap at time $t$ and $w_m$ denotes the weight for sectorial $m$. The equation for the equilibrium price in sector $m$ is given as:

$$p_{t,m}^{e} = p_t + b_i z_t + u_{t,m} \qquad (2)$$

where all these variables are stated in logs. $p_{t,m}^{e}$ is the equilibrium price in sector $m$ at time $t$, $p_t$ is the aggregate price index at time $t$, $b_m$ is the responsiveness of sector $m's$ equilibrium price to the business cycle, and $u_{t,m}$ represents idiosyncratic shock to sector $m$ at time $t$ with variance $\sigma_m^2$. The parameter $b_m$ is the percentage change in the sectorial price caused by the percentage change in the output gap. Equation (2) reveals that the optimal relative price in a sector is equal to the CPI plus the shape of the business cycle and idiosyncratic shocks.

First, responsiveness of sectorial prices with respect to changes in the business cycle is assessed, and essentially provides an indication of a sector's price changes in relation to the output gap. The output gap puts pressure on marginal costs and on the market powers of firms, and thus shifts the equilibrium price. In the general equilibrium model, changes in output gap also influence equilibrium prices through marginal costs. The response of the relative prices to the changes in business cycle is either countercyclical or pro-cyclical. To begin with the effects on the optimal target weights of cyclical sensitivity parameter $b_m$; if a sector price is more responsive to the business cycle, that sector's price should reveal higher optimal $w_m$ in the OSI. This suggests that optimal $w_m$ increases with an increase in $b_m$. Secondly, the level of noise (as measured by variance of idiosyncratic shocks) differs between the relative prices. The idiosyncratic relative price shock, known as sector supply shock, and represents the sectorial shock to productivity. It is a sector-specific error term, which captures idiosyncratic price dynamics that are not attributed to macroeconomic movements (Kaufmann and Lein, 2011). It reflects sectorial productivity and mark-up shocks. To consider the effects of idiosyncratic shocks on the optimal target weights; the larger the size of shocks in a sector, the lesser the importance that sector's price should receive in the OSI. This means that an increase in the variance of the sectorial shocks $\sigma_m^2$ decreases the optimal weight, $w_m$. Generally, when economists refer to sector prices as useful indicators for monetary policy, it is based on the fact that these prices have low noise (i.e. fewer idiosyncratic shocks as measured by $\sigma_m^2$). A large and unpredictable price change is likely to be accompanied by large idiosyncratic shocks, therefore carrying relatively small information about price trends which in turn leads to a small weight in the target index (Cecchetti et al., 2000). Thirdly, sectorial prices differ on the basis of their weights in the CPI constructed by the Bureau of Statistics. CPI is a measure that consists of average of a basket of consumer goods and services such as food, energy, medical services and education etc. The consumption weights are meant to reflect the relative importance of the goods and services as measured by their contributions in the total spending of households. As weights are based on the amount of money spent by the household on different goods, they are referred to as consumption (expenditure) weights. For sector $m$, the following relationship represents the standard CPI:

$$p_t = \sum_{m=1}^{M} \Phi_m p_{t,m} \tag{3}$$

where $\Phi_m$ is the relative percentage (consumption weight) of different sectors in the usual consumer's budget. In all the sectors, the CPI affects the equilibrium prices, demand and costs. A price sector with a comparatively high percentage in the CPI should receive low optimal weight. This means that an increase in consumption weight reduces the target weight. It has been suggested that a price index computed for the attainment of economic stability should also take into account consumption weights. Conversely, in the CPI, relative weights depend on the share of each product in the consumption budget of the ordinary consumer. This illustrates that constructing a price index for determining monetary policy should be different from the one meant for calculating the cost of living. Consumption weighting is positively related to sectorial shocks that result in unwanted movements in output and inflation. Through optimal policy making, the central bank should attempt to dampen the effect of these shocks on price equilibrium. For instance, measuring core inflation under IT is achieved by applying relatively less importance to, or permanently excluding, certain components of the price index on the grounds that their prices are considered to be unstable. The higher the shock the more problematic it appears to be. Therefore, to minimize effect of a shock, a central bank should reduce the weight of the sector in the target price index. Thus, keeping all the other characteristics constant sectors with a small share in the CPI is given a larger weight in the OSI.

Finally, the model considers that for each time period, there are some firms within an economy that gather updated information about the current state of the economy and adjust the optimal path of future prices. The remaining firms continue using their previous plans and thus set prices based on outdated information. The model focuses on the response of relative prices to changes in economic conditions. Some sector prices are flexible and others are sluggish. Sticky prices are slower than flexible prices to respond to changing economic conditions. Suppose $\Psi_m$ set prices based on advance plans and update information, and $(1-\Psi_m)$ is the part of sector $m$ that sets prices based on old information, the sector price is given as:

$$p_{t,m} = \Psi_m p_{t,m}^{E} + \left(1 - \Psi_m\right) E\left(p_{\mathrm{t},m}^{\mathrm{E}}\right) \tag{4}$$

where $E\left(p_{\mathrm{t},m}^{e}\right)$ denotes the expected value of equilibrium sectorial price and the parameter $\Psi_m$ measures sluggishness of prices in sector $m$. Smaller values for parameter $\Psi_m$ implies that relative prices do not react immediately to changes in economic conditions, while for a higher value of $\Psi_m$ (approaching 1) the sector's actual price is closer to its equilibrium price level. This is consistent with the literature as responsiveness of output and magnitudes of the shocks are the determining factors for the weights to be assigned to price indices. Therefore, in cases of price sluggishness, smaller values of $\Psi_m$ raise the optimal weight $w_m$. That is, the less flexible a sector's price is, the more weight that sector's price is given in the OSI.

### 2.1. Optimal Weights for the Stability Price Index

The solution to the central banks' problem will result into set of optimal weights in a target price index which depends on the sector characteristics, including $b_m, \Phi_m$ $and$ $\Psi_m$. These sectorial characteristics of the parameters are considered as exogenous in the model. The OSI is the weighted average of sectorial prices. It is assumed that the central bank maintains a weighted mean of prices at a given level to target inflation, which can be set equal to zero without the loss of generality. This can be described as:

$$\overline{p}_t = \sum_{i=1}^{I} w_m p_{t,m} \tag{6}$$

where $\overline{p}_t$ is the *OSI*, and $w_m$ is the target weight in sector *m*. The sum of the target weights $w_m$ is equal to one.

$$\sum_{m=1}^{M} w_m = 1 \tag{7}$$

The paper derives four sectorial functions addressing the problem faced by the central banks. It should be noted that the algebraic solution that is used here is a lengthy and time-consuming process. The following assumptions are used in deriving the four-sector solution:

i. There are only four sectors, called sectors 1, 2, 3 and 4$(m = 1,2,3,4)$.
ii. The sectorial shocks $(u_1, u_2, u_3, u_4)$ are uncorrelated[4].
iii. The cyclical sensitivity parameters $b_1, b_2, b_3$ and $b_4$ are all greater than zero.

First step is to derive all variables as deviations from their mean value. This is called deviations form (disturb variable) of each variable and is denoted by letting tilde over the variables such as:

$$\widehat{z_t} = z_t - E(z_t),\ \widehat{p_{t,m}} = p_{t,m} - E(p_{t,m}),\ \widehat{p_t} = p_t - E(p_t) \text{ and } \widehat{u_{t,m}} = u_{t,m} - E(u_{t,m}).$$

The expected value of all variable in the deviation form is zero. Therefore, the model can be express as;

$$\widehat{p_{t,m}} = \widehat{p_t} + b_i \widehat{z_t} + \widehat{u_{t,m}} \tag{8}$$

$$\widehat{\mathrm{p}_{\mathrm{t,m}}} = \Psi_{\mathrm{m}}\ \widehat{\mathrm{p}^{\mathrm{e}}_{\mathrm{t,m}}} + (1-\ \Psi_{\mathrm{m}})\mathrm{E}\left(\widehat{\mathrm{p}^{\mathrm{e}}_{\mathrm{t,m}}}\right) \tag{9}$$

$$\widehat{p_t} = \Phi_1 \widehat{p_{t,1}} + \Phi_2 \widehat{p_{t,2}} + \Phi_3 \widehat{p_{t,3}} + \Phi_4 \widehat{p_{t,4}} \tag{10}$$

$$0 = w_1 \widehat{p_{t,1}} + w_2 \widehat{p_{t,2}} + w_3 \widehat{p_{t,3}} + w_4 \widehat{p_{t,4}} \qquad \left(\sum_{m=1}^{M} w_m \tilde{p}_{t,m} = 0\right) \tag{11}$$

The model considers four sectors in derivation$(m = 1,2,3,4)$ in which the average of the weights is equal to unity. The model is written as;

$$\widehat{p_{t,m}} = \Psi_m(\widehat{p_t} + \beta_1 \widehat{z_t} + \widehat{u_{t,m}}), \qquad 12)$$

$$\widehat{p_t} = \sum_{m=1}^{3} \Phi_m \widehat{p_{t,m}} + (1 - \Phi_1 - \Phi_2 - \Phi_3)\widehat{p_{t,4}}, \tag{13}$$

4 This assumption is used to obtain a straightforward theoretical solution, while the empirical analysis does not use this assumption, and therefore estimates the target weights for sector prices with both correlated and uncorrelated shocks.

$$0=\sum_{m=1}^{3} w_m \widehat{p_{t,m}}+(1-w_1-w_2-w_3)\widehat{p_{t,4}}, \tag{14}$$

where, $w_4=(1-w_1-w_2-w_3)$ and $\Phi_4=(1-\Phi_1-\Phi_2-\Phi_3)$. Equation (12) is solved for the equilibrium sectorial prices.

Substituting the equilibrium sectorial prices into equation (14) and solving for variable $(\widehat{z_t})$, with respect of the parameters $(b_m, \Phi_k, \Psi_k, w_k)$ and the shocks $(u_m)$. Taking unconditional expectation of the square of output gap, the variance of output gap is obtained as a function of $b_k, \Phi_k, \Psi_k, w_k$ and the variance of $E(\widehat{u_k})^2=\sigma_m^2$ but the covariances of the shocks are uncorrelated, i.e. $\left[\mathrm{E}(\widehat{\mathrm{u}_{\mathrm{m}}},\widehat{\mathrm{u}_{\mathrm{j}}})=\sigma_{\mathrm{mj}}=0\right]$.

$$Var(\widehat{\mathrm{z}})=\frac{\left[\begin{array}{l}\sigma_1^2\left\{\Psi_1\begin{pmatrix}w_1+\Psi_4(\Phi_1-w_1)+(\Psi_3-\Psi_4)(w_3\Phi_1-w_1\Phi_3)+(\Psi_2-\Psi_4)\\(w_2\Phi_1-w_1\Phi_2)\end{pmatrix}\right\}^2+\\ \sigma_2^2\left\{\Psi_2\begin{pmatrix}w_2+\Psi_4(\Phi_2-w_2)+(\Psi_3-\Psi_4)(w_3\Phi_2-w_2\Phi_3)+(\Psi_1-\Psi_4)\\(w_1\Phi_2-w_2\Phi_1)\end{pmatrix}\right\}^2+\\ \sigma_3^2\left\{\Psi_3\begin{pmatrix}w_3+\Psi_4(\Phi_3-w_3)+(\Psi_1-\Psi_4)(w_1\Phi_3-w_3\Phi_1)+(\Psi_2-\Psi_4)\\(w_2\Phi_3-w_3\Phi_2)\end{pmatrix}\right\}^2+\\ \sigma_4^2\left\{\Psi_4\begin{pmatrix}1+\sum_{m=1}^{3}\Psi_m w_m-\sum_{m=1}^{3}\Psi_m\Phi_m-\sum_{m=1}^{3}w_m+(\Psi_1-\Psi_3)(w_3\Phi_1-w_1\Phi_3)\\+(\Psi_1-\Psi_2)(w_2\Phi_1-w_1\Phi_2)+(\Psi_2-\Psi_3)(w_2\Phi_3-w_2\Phi_3)\end{pmatrix}\right\}^2\end{array}\right]}{\left[\begin{array}{l}\Psi_4 b_4+\sum_{m=1}^{3}b_m\Psi_m w_m - b_4\Psi_4\sum_{m=1}^{3}w_m - \Psi_1\Psi_3\{(b_1-b_4)(\Phi_1 w_3-\Phi_3 w_1)\}+\\ \Psi_3\Psi_4\{(b_3-b_4)((\Phi_1 w_3+\Phi_2 w_3-\Phi_3 w_1-\Phi_3 w_2)+(\Phi_3-w_3))\}+\\ \Psi_2\Psi_3\{(b_2-b_3)(\Phi_2 w_3-\Phi_3 w_2)\}+\Psi_1\Psi_2\{(b_1-b_2)(\Phi_1 w_2-\Phi_2 w_1)\}+\\ \Psi_1\Psi_4\{(b_1-b_4)((\Phi_3 w_1+\Phi_2 w_1-\Phi_1 w_2-\Phi_1 w_3)+(\Phi_1-w_1))\}+\\ \Psi_2\Psi_4\{(b_2-b_4)((\Phi_1 w_2+\Phi_3 w_2-\Phi_2 w_1-\Phi_2 w_3)+(\Phi_2-w_2))\}\end{array}\right]^2} \tag{15}$$

Given values for these parameters $(b_m, \Phi_m, \Psi_m, \sigma_m^2)$ then minimize the variance of output gap with respect to the $w_1, w_2, w_3$ and $w_4$, subject to the constraint that sum of weights are equal to one i.e. $\sum_{m=1}^{M} w_m=1$ and probably imposing non-negative constraints $(w_k \geq 0)$. The desire optimal weights can be obtained. These optimal target weights are denoted by $w_1, w_2, w_3$ and $w_4$ for sectors 1, 2, 3 and 4 respectively. These are functions of the sectoral characteristics.

## 3. Stock Markets, Data Description and Estimation Procedure

The data-set consists of quarterly series covering the period 1981:1 to 2012:1. As discussed in Section 2, the paper is interested in analyzing four sector price model: the prices of energy, food, other goods and services and the stock market in order to design a price index for use by the central bank. In addition, the data-set also contains output gap and CPI for the respective countries. The food, energy and other goods variables are sourced from the OECD database[5]. The study utilizes the weights of different sectors in the typical consumer's budget for both countries, which are taken from the OECD. Our analysis requires the basket weight for one time period, but for the robustness checks, different periods' consumption weights were also used. However, the results indicate no significant difference. Hodrick-Prescott (HP) filter was used to obtain the output gaps for the countries. Real GDP series were generated by deflating nominal GDP of the countries by using their respective GDP deflator sourced from IMF International Financial Statistics (IFS)[6] as well as the stock price indices that proxied for the asset prices. Stock indices are used because stock constitutes more than fifty percent of the assets managed and traded in these countries. The stock price variables are the capitalization-weighted index of the top 500 large companies listed stocks in the US (quarterly average of S&P 500 price index), while for the UK, quarterly average of FTSE all Share price index is used[7]. S&P is used because of its diversity relative to either Dow Jones or NASDAQ. Similarly, FTSE All Shares is preferred to FTSE 100 as the former is more inclusive than the latter in terms of their coverage.

Stock Markets provide two essential functions as market securities and a price mechanism. The former maintains liquidity, which encourages investors to trade financial assets. The latter on the other hand, it determines assets prices that reflect the true investment value of the assets. Generally stock market is regarded as a good indicator of the economy's performance. Huge downward swings are regarded as sign of a future economic recession while the opposite is seen as signal for future economic growth. This view is backed by the argument that stock prices incorporate future corporate earnings that is related to future

[5] http://stats.oecd.org
[6] https://stats.ukdataservice.ac.uk/index.aspx?r=668730&DataSetCode=IFS#.
[7] The UK Share Price used is the FTSE All-Share Index, which is a market capitalization weighted index representing the performance of all eligible companies listed on the London Stock Exchange's main market.

output growth. Stock markets affect the economy via two channels. The first channel is through the wealth effects and secondly they are seen as avenues through which consumers and corporate organizations express their confidence on the economy. For example, as argued by PWC (2013) both the US and the UK stock markets recorded resilient rises during the fourth quarter of 2013 through to the middle of first quarter of 2013. This is so even in the face of negative growth reported by the countries for the period.

The UK and the US stock markets are among the largest, with an average market capitalization of about 129% and 120% of their GDP between 2000 and 2012, respectively. The high capitalization ratio in the figure for both countries reflects the high level of financial development and integration. Figure 1 shows the size of the stock markets for the two countries for 1990-2012. This contrasts so much with other countries. For example, that of Austria that was just about 17% for the same period. In addition, they also host very prominent and largest stock exchanges in the world and IT regime has been well established into their monetary policy. The stock markets in these countries have played significant role in determining the state of their economies for about a century (Bordo and Wheelock, 2006). Similarly, Hsing (2011) has found that the US stock market index is positively associated with it real GDP.

Figure 1

Excessive volatility that characterised stock prices could make it difficult for central banks to construct a reliable price index that incorporates stock prices. It is in this line that Shiratsuka (1999) opines that CPI is more reliable than stock price indices. However, Goodhart (2001) had presented alternative weighting scheme that accommodates stock price indices. Based on that, he argues that policy makers should consider a similar broader price index. In line of these arguments, this paper adopts an approach similar to that of Anderson and Subbaraman (1996) that decomposes the stock price index into fundamental and non-fundamental (bubble) components.[8] HP-filter technique was used to decompose the stock price into fundamental

[8] Anderson and Subbaraman (1996) divided the fundamental and speculative components of share prices and found that only the former has an impact on investment.

and bubble components[9]. This distinguishes cyclical behaviour of the stock price from the long run path of the series.

As discussed in Section 2, the optimization approach developed to estimate target weights applied to different sectors in the price index, where the goal of the central bank is to stabilize the real economy. The problem is how to correctly measure the key sectoral parameters. Mankiw and Reis (2003) explain that it is very difficult to estimate all the relevant sectoral parameters. The methodology proposed by Charemza and Shah (2013), which identifies an appropriate method for the estimation of the model was adopted here. The parameter $\Psi_m$, , which measures the degree of price sluggishness, depends on assumptions that some sector prices are fully flexible while other prices are sluggish. For completely flexible sectors such as food and energy prices, it is assumed that $\Psi_m = 1$. This signifies price setting in these sectors is completely dependent on real economic condition. For sluggish sectors such as other goods and services, and stock prices, it is assumed that $\Psi_m = 0.5$. For sensitivity analysis, intervals [0.9, 1] and [0.45, 0.55][10] for price sluggishness highly flexible parameters were used. This is repeated by 15000 sampling draws.

Next step is to obtain the parameters $b_m$ and $\sigma_m^2$. Equation (16) was used to obtain the shocks by estimating a autoregressive model, AR containing $p_{t,m}$, $p_{t,}$ and $z_{t,}$. In other words, the original data have been sifted from the shocks.

$$p_{t,m} - E(p_{t,m}) = \Psi_m\left(p_t - E(p_t)\right) + b_m \Psi_m\left(z_t - E(z_t)\right) + \Psi_m\left(u_{t,m} - E(u_{t,m})\right) \tag{16}$$

where all the variables as defined. It states that the price disturbance in sector $m$ depends on the aggregate price disturbance, output disturbance and shock. These disturbance variables are obtained by taking residuals from the corresponding regressed variables $p_{t,m}$, $p_t$ and $z_t$ on a constant, a time trend and their own lags. The optimum lags are determined by the information criteria. The major concern in obtaining these parameters is that the shocks are likely to be correlated with the CPI. This identification problem makes it harder to estimate the correct parameters. To address this potential problem this paper formulates appropriate sectoral disturbance variables. These sectoral disturbance variables (rearrange eq. 16) are

[9] Hodrick and Prescott (1997) proposed a filter, usually referred to as the HP-filter that estimates an unobservable time trend (growth) component of given time series variable.

[10] Followed to Charemza and Shah (2013).

calculated by dividing the sluggishness parameter in sector $m$ and subtracting from the aggregate price disturbance $\left(\frac{\widehat{p_{t,m}}}{(\Psi_m)} - \widehat{p_t}\right)$ where the rigidity parameter for each sector is independent from aggregate price. Thus, equation (16) can be re-written as:

$$\widehat{p_{t,m}} = b_m \widehat{z_t} + \widehat{u_{t,m}} \tag{17}$$

All the estimations used these residuals (disturbance variables) as the data set. It is assumed that estimated shocks $\widehat{u_{t,m}}$ are idiosyncratic. The explanatory variable, output gap $\widehat{z_t}$ data is observed as a disturbance variable. It is likely that idiosyncratic shocks are correlated with non-idiosyncratic components, thus causing another identification problem making formal estimation difficult. Equation (17) allows the possibility that some or all elements of the explanatory variable may be related with idiosyncratic shocks (composite error). This is the main source of endogeneity for certain explanatory variables in the regression equation. The estimation was undertaken through GMM techniques as suggested by Ogaki (1993), which is capable of computing the cyclical sensitivity and variance of the idiosyncratic shocks parameters. In addition, GMM has advantages over maximum likelihood or two-stage least square within the context of this analysis, because the technique allows estimation under restrictions implied by the economic theory and at the same time, it does not require additional distributional assumptions, which may not be part of the theory (Wooldridge, 2001). The explanatory variable (instrument variable) is orthogonal to the disturbance term $E[\widehat{z_t}(\widehat{p^e_{t,m}} - b_m \widehat{z_t})] = 0$. The parameter $b_m$, is estimated so that the corresponding sample moments are close to zero. The parameter of consumption weight $\Phi_m$ is the relative percentage of each sector in the CPI. The consumption weight for stock prices is zero. After assigning the parameters to the four sectors these are then substituted into the variance of the output gap in equation (15). Then the variance of the output gap in equation (15) is numerically minimized with respect to $w_m$. For optimization, the paper uses Newton-Raphson algorithm that is an iterative procedure that calculates maximum likelihood estimates. This is subject to restrictions where the sum of the weights is equal to unity, $\left(\sum_{m=1}^{M} w_m = 1\right)$ and additionally the non-negative optimal weights $(w_m \geq 0)$. The cyclical sensitivity parameters are all greater than zero. Finally, the relative variance of output gap is estimated from OSI and CPI respectively for comparison. This is done to check how far the variance of output gap is minimized by targeting OSI rather than CPI. The variance of output gap for the OSI is estimated by replacing the four sectors' parameters and optimal weights in the objective function in equation (15). This procedure first involves estimating all the parameters and optimal weights for each sector. Then, it is substituted in all the parameters in the objective function equation (15). However, output gap variance is estimated for the CPI by evaluating the objective function where the optimal weights are equal to the consumption weights. Additionally, the parameters and consumption weights for stock price are equal to zero because this is not a component of CPI.

## 4. Discussions of the Empirical Results

As discuss in Section 3, optimization techniques were used to compute weights for different sectors in the price index from the perspective that policy maker aims to minimize variability of output gap. Parameters are assigned to the four sectors considered. Table 1 reports the results for the sectoral parameters for the UK and the US. Three regressions were estimated where in the first one stock prices, in addition to energy, food and other goods and services is included. The second and the third ones used fundamental stock prices and bubble prices, respectively.

Table 1

The cyclical sensitive parameter $b_m$ for the energy sector is larger than most of the other sectors for both countries (except for financial sector in UK). But the magnitude of the sectoral shock $\mathrm{var}(u)$ and consumption weight for energy sector is high. As mentioned in the theoretical model, the parameter of cyclically sensitive $b_m$ should be pro-cyclical (greater than zero). For US, the parameter value $b_m$ for food and other goods sector are zero, which signifies that they are countercyclical. The consumption weight $\Phi_m$ and the variance of sectoral shocks for food are lower than all other sectors. However, the combination of a low $b_m$ and a higher value of $\Psi_m = 1$ suggest that the food sector is less desirable sector for use as a component of the OSI. As expected for both countries, stock prices and their components (fundament and bubble) responded significantly to output gap and large idiosyncratic shocks $\mathrm{var}(u)$, as evident in Table 1. The large sensitivity to the output gap is due to large cyclical movements in stock prices as high volatilities and non-systemic movements in stock prices would lead to large idiosyncratic shocks. Therefore, stock prices need to be assigned a relatively higher optimal weight in the OSI despite their showing a large variance in sectoral shocks. These obtained numerical parameter values are substituted in the equation (15) and minimized with and without the constraints. Table 2 shows the average optimal OSI and CPI weights and output variance from 15,000 optimization experiments in case of correlated shocks. The correlation between the shocks is reported in Appendix A, Tables (A1) and (B1). Three sets of optimal weights for OSI were computed.

To check for robustness of the results, more optimization experiments for different possible combinations were carried out; first, one-time period CPI weights for year 2000 was used as well as using CPI for different years' weights. This is because one might suspect that a CPI weights are largely responsible for the high target weight. The result indicates that changing the CPI weights have not significantly affected the optimal weights and output reductions. Secondly, shocks were supposed to be uncorrelated rather than correlated as assumed in the first model, but shocks were allowed to be correlated and it has not affected the results in any significant way. Finally, optimal weights were assumed to be negative, but the results remain more-or-less similar. Therefore, in all these cases the findings are robust as they consistently show that OSI still achieves reduction in output variance for both countries.

Table 2

The UK results are more interesting than those of the US as reported in Table 2. The results show that stock prices obtain 9% weights in the OSI, which is attributable to the combination of the high pro-cyclical sensitivity, zero CPI weight and less flexibility parameters. The OSI assigns 51% and 25% optimal weights to food and energy sector respectively. Output gap variations are significantly smaller (about 146% less) in the model that used OSI than the one used the CPI. In addition, stability in the real economic activities further increases when fundamental stock prices are used as a component in the OSI for the UK rather than the stock prices or the bubble component of the stock prices. The reduction in output-gap variability is more than 10 times in OSI than that of the CPI. The explanation lies in the fact that price index calculated using the fundamental stock price is more reliable than the one that used actual or bubble stock prices. This is suggests that as movements in the fundamentals are more systematic and reflect permanent changes, should be given more weight by the policy makers.

The results for the US show that other goods sector obtain higher weights 90% in the OSI, which could be due to the combination of the low $\Psi_m$ and small variance of shocks. The combination of high $b_m$, low $\Psi_m$ and zero consumption weights give some weight to stock prices in the OSI. For oil-importing US the optimal weight is 7% for the energy sector is due to the higher $b$ and lower $\Phi_m$. The results indicate that the US the output gap variance calculated from the OSI is about 18% smaller than the one from the CPI. The findings suggested that the price index of central banks could minimize economic instability by giving some weight to stock prices. Although stock price get very small optimal weight only 1% but resetting the weights in the price index would leads to a significant gain in terms of economic stability. The findings, in general signify that rearranging the weights in the price index to include financial sector similar to that of the OSI would lead to a sizeable gain in terms of output stability in both countries. Over all, the results Table 2 shows that output gap variance reduction is higher in the OSI than in the CPI in both countries. Hence, this suggests that an OSI as an index targeted by the policy makers would bring about improvement in economic stability rather than the CPI, which may be better used as a measure of cost of living.

Inflation for the two countries is computed using the OSI and the CPI. These are depicted in Figures 2(a) and (b). The computed inflation is defined by the percentage change in the CPI and the OSI over the last year's level in the corresponding quarter. As shown in Figure 2(a), the result for the UK shows large divergence between OSI inflation and headline inflation from the start 2000s and the late 2000s. The growth rate of OSI turned negative from 2001 to 2003. It can therefore be stated that monetary policy focusing on the stabilization of OSI inflation would observe accelerating stock inflation during the late 1990s. Figure (2b) shows that the inflation rates measures by the OSI and CPI inflation series in the US are almost identical and do not fundamentally differ. The main intuition is that OSI and CPI got most of the weight from other good sectors. However, the result shows that resetting the weights in the price index of the US leads to substantial reduction in output variance.

Figure 2

## 5. Conclusion

Our finding suggests that a central bank aiming to achieve maximum economic stability should include stock prices as a component in the index and attribute substantial weight to them when targeting inflation. For both countries moving from a policy of using CPI to use of the OSI, the stability of real economy is generally seen to increase. This evidence provides validity to the current approach with regards to macroeconomic stability by computing smaller variances in a country's output gap by using OSI rather than CPI. This approach is also attractive in the sense that a carefully constructed OSI can combine different sectoral prices in such a way that the correlation between shocks among the various sectors is offset. This also suggests that potential improvements in economic stability might be achieved by targeting OSI, rather than the tradition CPI. The computing OSI is of critical important for UK and US, as their economies are highly dependent on variations in the stock market. For UK, reduction in output variance is significantly larger by using the fundamental components in the OSI. The intuition behind this result is that the fundamental stock prices have smaller sectoral shocks which make them a more useful predictive tool for authorities when implementing monetary actions through changes in interest rates.

In the introduction, this paper set out some general arguments concerning the inclusion of financial sector in measures of price indices, and the response of monetary policy to stock prices. The arguments against this approach state that the assessment of asset prices depends on future expectations. Such expectations about asset prices are very difficult to measure, in that the *ex-ante* is not necessarily equivalent to the ex post. In contrast, the arguments in favour claim that monetary authorities should react to asset price movements to help minimize the risk of variations in output, and the asset price is an efficient indicator for predicting future inflation.

To summarize, the empirical results from the estimated models allow the illustration of certain policy conclusions. IT helps to provide macroeconomic stability and also implies that interest rates will tend to rise during asset price booms and fall during asset prices busts. Hence, a monetary policy maker trying to monitor an OSI will also observe stock price fluctuations. For instance, in UK during the financial crisis of 2007-08 stock prices rose relative to other prices. Policy makers could have reacted by rising interest rates to counter increasing stock prices, which would potentially have avoided large fluctuations in output. In contrast, if stock prices are decreasing faster than other prices then the central bank should react by falling interest rates. Paying such attention to the OSI should minimize the likelihood of future booms and busts in stock prices.

One potential concern about using SPI to maximize economic stability, while giving considerable weight to financial sector, is that this approach might not be realistic for countries with smaller stock markets. However, the recent increase in the relevance of stock market prices to the overall well-being of the global economy, OSI may be a very useful indicator for monetary policy implementation for the majority of countries in the world. Furthermore, with improvement in empirical estimation techniques one can estimate accurate weight for stock prices in the overall price index. For example, the method HP-filter applied to compute decomposition of the stock prices (into fundamental and bubble components) in this paper is fairly simple and can be further improved. A possible extension of this paper is that the number of sectors in the analysis can be increased (to include nominal wages, hour prices, tradable and non-tradable goods etc.) to estimate the OSI for central bank targeting. It should be noted that increased numbers of sectoral prices would require a lengthy algebraic solution to the central banks' problem, presenting a considerable programming challenge.

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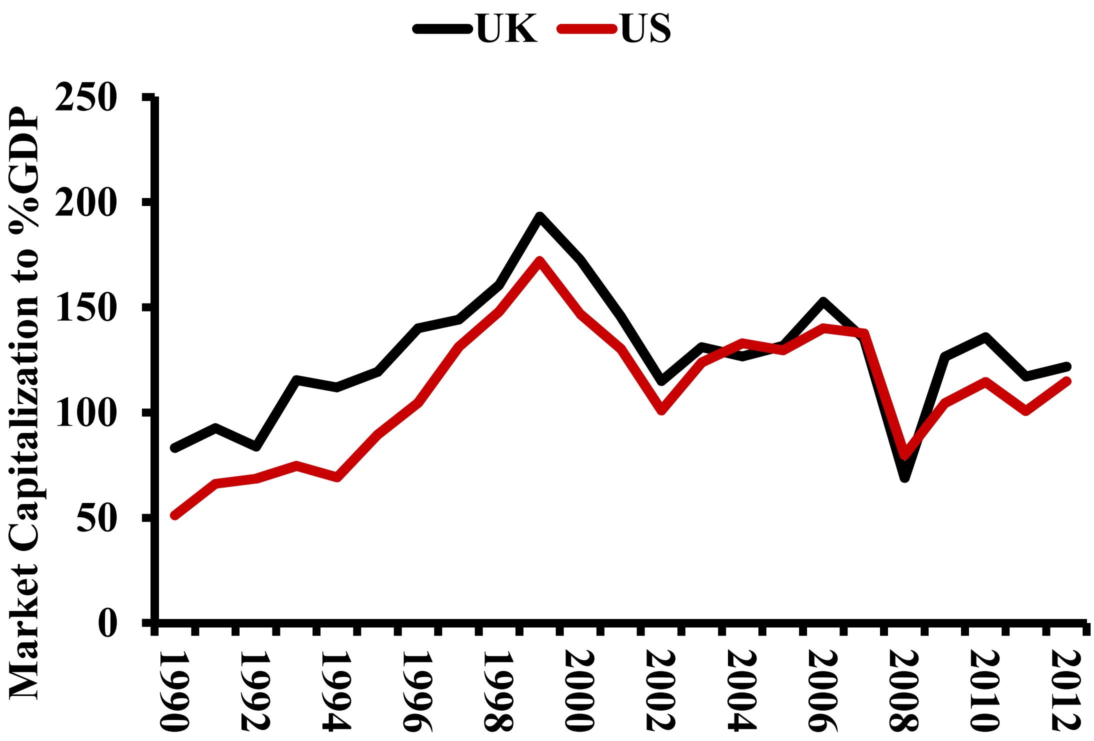
**Figure 1: Ration of Stock Market Capitalization to GDP for UK and US, 1990-2012**




Source: World Development Indicator Database

**Figure 2. Comparison of the OSI and the CPI inflation**

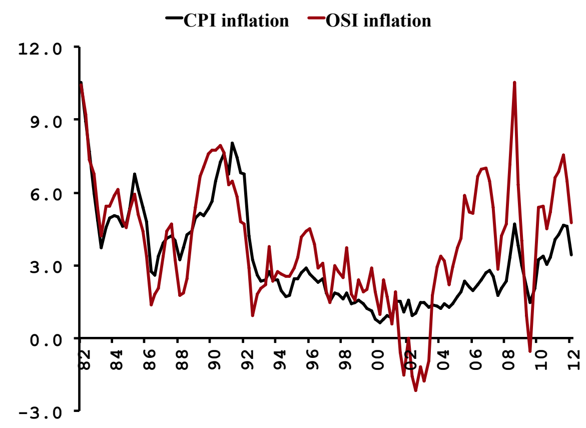
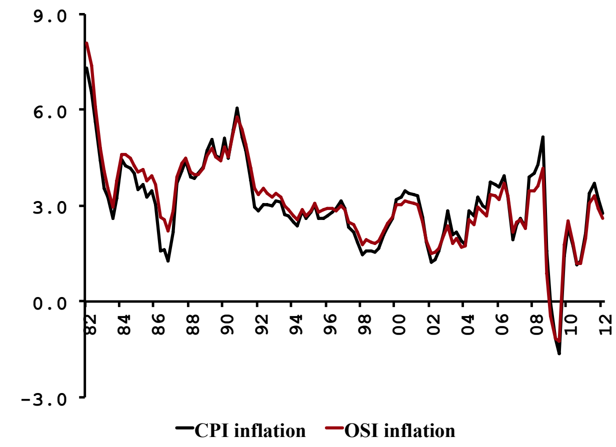
| (a) UK | (b) US |
|---|---|
|  |  |

**Table 1: Summary of the Sectoral Parameters**

| Sector | UK | | | | US | | | |
|---|---|---|---|---|---|---|---|---|
| | $b$ | Var(u) | $\Psi$ | $\Phi$ | $b$ | Var(u) | $\Psi$ | $\Phi$ |
| Food | 1.50 | 0.000095 | 1.0 | 0.11 | 0.00 | 0.000071 | 1.0 | 0.10 |
| Energy | 2.70 | 0.000342 | 1.0 | 0.07 | 23.55 | 0.002171 | 1.0 | 0.08 |
| Other goods | 0.01 | 0.000051 | 0.5 | 0.82 | 0.00 | 0.000010 | 0.5 | 0.83 |
| Stock | 20.63 | 0.013490 | 0.5 | 0.00 | 5.86 | 0.012670 | 0.5 | 0.00 |
| Fundament | 13.20 | 0.002285 | 0.5 | 0.00 | 1.87 | 0.002076 | 0.5 | 0.00 |
| Bubble | 3.46 | 0.010460 | 0.5 | 0.00 | 8.18 | 0.007729 | 0.5 | 0.00 |

**Table 2: Weights, CPI and Optimal, From Constrained Optimisation For Mean Lambdas and Sensitivity Standard Errors (Correlated Shocks)**

| | Food | Energy | Other goods | fin.sec | output.var | var.reduction |
|---|---|---|---|---|---|---|
| | | | **UK** | | | |
| CPI | 0.11 | 0.07 | 0.82 | 0.00 | 0.000079 | 1.00 |
| OSI (sto) | 0.51 | 0.25 | 0.15 | 0.09 | 0.000032 | 2.46 |
| sse | (0.014) | (0.020) | (0.035) | (0.012) | | |
| OSI (fun) | 0.37 | 0.18 | 0.13 | 0.32 | 0.000007 | 10.62 |
| see | (0.019) | (0.012) | (0.019) | (0.023) | | |
| OSI (bub) | 0.44 | 0.33 | 0.24 | 0.00 | 0.000071 | 1.12 |
| see | (0.014) | (0.030) | (0.029) | (0.000) | | |
| | | | **US** | | | |
| CPI | 0.10 | 0.08 | 0.82 | 0.00 | 0.0000019 | 1.00 |
| OSI (sto) | 0.02 | 0.07 | 0.90 | 0.01 | 0.0000015 | 1.18 |
| | (0.003) | (0.011) | (0.014) | (0.001) | | |
| OSI (fun) | 0.02 | 0.07 | 0.88 | 0.03 | 0.0000025 | 0.75 |
| | (0.003) | (0.01) | (0.013) | (0.001) | | |
| OSI (bub) | 0.02 | 0.07 | 0.90 | 0.01 | 0.0000039 | 0.49 |
| | (0.004) | (0.012) | (0.013) | (0.002) | | |

The numbers in brackets are the standard error, sto stands for stock prices, fun denotes fundamental stock prices and bub represents bubble stock prices.

# Appendix A

### Table A1 - Correlation Matrix of Shock for UK

| Sector | House & Energy | Food | Other goods | Stock |
|---|---|---|---|---|
| Energy | 1.0000 | -0.5346 | 0.2514 | -0.0525 |
| Food | | 1.0000 | -0.7876 | 0.1512 |
| Other goods | | | 1.0000 | -0.2474 |
| Stock | | | | 1.0000 |

### Table A2 - Correlation Matrix of Shock for US

| Sector | Energy | Food | Other goods | Stock |
|---|---|---|---|---|
| Energy | 1.0000 | -0.4381 | -0.0586 | 0.0634 |
| Food | | 1.0000 | -0.3543 | 0.0950 |
| Other goods | | | 1.0000 | -0.0423 |
| Stock | | | | 1.0000 |